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[Name of Document]	Drawings	1
[Name of Document]	Abstract	1

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[Name of Document] SPECIFICATION

[Title of the Invention] RF MODULE

[Claims]

[Claim 1] An RF module comprising; a substrate, and a BBIC, a memory IC, an RFIC and an RF passive component which are mounted on said substrate;

wherein a multi-layered substrate is used as said substrate; and

wherein said RF passive component and a wiring pattern including the wiring pattern interconnecting said BBIC and said memory IC are incorporated in said multi-layered substrate.

[Claim 2] An RF module according to Claim 1, wherein an antenna is incorporated in said substrate.

[Claim 3] An RF module according to Claim 1 or 2, wherein at least one of said BBIC, said memory IC and said RFIC is a bare chip.

[Claim 4] An RF module according to Claim 3, wherein at least one cavity is formed in a part of said substrate, and said bare chip is embedded in said cavity.

[Claim 5] An RF module according to any of Claims 1 to 4, wherein said BBIC and said memory IC are mounted on one side of said substrate, and said RFIC is mounted on the other side of said substrate.

[Claim 6] An RF module according to Claim 5, wherein said

BBIC and said memory IC are formed on one layer of said multi-layered substrate while said RF active component is formed on a different layer of said multi-layered substrate, and a shielding ground pattern ~~is formed~~ between said BBIC and said memory IC, and said RF active component.

[Claim 7] An RF module according to any of Claims 1 to 6, wherein at least one trimming electrode pattern is formed on the surface of said substrate, for the purpose of adjusting oscillation frequency and filter characteristics by trimming.

[Claim 8] An RF module according to Claim 4, wherein said RFIC is a bare chip, and, in order to prevent unnecessary radiation of RF signals, an RF signal radiation prevention ground pattern is provided on the bottom side of said bare chip in said substrate, said substrate having a plurality of via holes arranged around said bare chip, said via holes providing connection to said ground electrode pattern for preventing RF signal radiation.

[Claim 9] An RF module according to Claim 1, wherein a metallic case which also serves as an antenna is formed on said substrate.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to an RF module and, more particularly, an RF module which has ICs such as an RFIC,

BBIC (Base Band IC), and a memory IC mounted on a substrate, and which is used in a mobile terminal typically represented by a Bluetooth.

[0002]

[Description of the Related Art]

RF modules have been developed which are intended for use in Bluetooth systems. Such an RF module typically has components such as an RFIC, BBIC, memory IC and a quartz oscillator which are mounted on a substrate.

[0003]

[Problems to be Solved by the Invention]

A conventional RF module of a type which is not equipped with an antenna has dimensions of 33 mm long, 17 mm wide and 3.65 mm thick. An RF module of a type having an antenna built-in in the substrate has dimensions of 32 mm long, 15 mm wide and 2.9 mm thick is also available. These RF modules are too large to be mounted in, for example, a mobile telephone.

[0004]

Accordingly, it is a primary object of the present invention to provide an RF module which can be implemented with reduce dimensions.

[0005]

[Means for Solving the Problems]

An RF module in accordance with the present invention

comprises; a substrate, and a BBIC, a memory IC, an RFIC and an RF passive component which are mounted on the substrate; wherein a multi-layered substrate is used as the substrate; and wherein the RF passive component and a wiring pattern including the wiring pattern interconnecting the BBIC and the memory IC are incorporated in the multi-layered substrate.

In the RF module of the present invention, an antenna may be incorporated in the substrate.

In the RF module of the present invention, at least one of the BBIC, the memory IC and the RFIC may be a bare chip. In this case, the arrangement may be such that at least one cavity is formed in a part of the substrate, and the bare chip is embedded in the cavity.

In the RF module of the present invention, the arrangement may be such that the BBIC and the memory IC are mounted on one side of the substrate, and the RFIC is mounted on the other side of the substrate. In such a case, the RF module may be configured such that the BBIC and the memory IC are formed on one layer of the multi-layered substrate while the RF active component is formed on a different layer of the multi-layered substrate, and a shielding ground pattern is formed between the BBIC and the memory IC, and the RF active component.

In the RF module of the present invention, at least one

trimming electrode pattern may be formed on the surface of the substrate, for the purpose of adjusting oscillation frequency and filter characteristics by trimming.

In the RF module of the present invention, the arrangement may be such that the RFIC is a bare chip, and, in order to prevent unnecessary radiation of RF signals, an RF signal radiation prevention ground pattern is provided on the bottom side of the bare chip in the substrate, the substrate having a plurality of via holes arranged around the bare chip, the via holes providing connection to the ground electrode pattern for preventing RF signal radiation.

In the RF module of the present invention, a metallic case which also serves as an antenna may be formed on the substrate.

[0006]

In the RF module of the present invention, a multi-layered substrate is used as the substrate, and the RF passive component and a wiring pattern including the wiring pattern interconnecting the BBIC and the memory IC are incorporated in the multi-layered substrate. Therefore, the RF module of the present invention is reduced in size as compared with conventional RF modules and can suitably be mounted in, for example, a mobile phone.

[0007]

The above and other objects, features and advantages of

the present invention will become clear from the following description of the embodiments taken in conjunction with the accompanying drawings.

[0008]

[Description of the Embodiments]

Fig. 1 is a front elevational diagrammatic illustration of an RF module of the present invention, while Fig. 2 is a circuit diagram of the RF module. The RF module 10 shown in Fig. 1 has a multi-layered substrate 12 made of, for example, ceramics.

[0009]

A BBIC 14, a memory IC 16, a quartz oscillator 18 and surface-mount components 20 are mounted on the upper side of the multi-layered substrate 12. The BBIC 14 is responsible for the overall control of the RF module 10. The memory IC 16 is, for example, a flash memory which stores control software. The quartz oscillator 18 is used as a reference oscillator. The surface-mount components include electronic components such as an inductor, a capacitor, a resistor, a transistor, and a diode.

[0010]

A metallic case 22 is secured to the upper side of the multi-layered substrate 12, so as to cover the BBIC 14, memory IC 16, quartz oscillator 18 and the surface-mount components 20.

[0011]

A cavity 24 is formed in the lower side of the multi-layered substrate 12 at a central portion thereof. A first RFIC 26 and a second BFIC 28 are embedded in the cavity 24. The first RFIC 26 and the second RFIC 28 may be, for example, bare chips. The first RFIC 26 and the second RFIC 28 are covered with a resin 30 which fills the cavity 24.

[0012]

Wiring patterns 34 and through-holes 34 interconnecting the BBIC 14 and the memory IC 16, RF passive components 36, and a shielding ground electrode pattern 38 are formed internally of the multi-layered substrate 12. The RF passive components 36 include, for example, an inductor, a capacitor, a distributed-constant line, a resonator, a filter, and a balun. The shielding ground electrode pattern 38 is formed between the BBIC 14 and the memory IC 16, and the RF passive components 36.

[0013]

By way of example, the RF module 10 has a circuit of a full device 1 shown in Fig. 2.

[0014]

This RF module 10 has a smaller size than conventional RF modules and, therefore, can be mounted in a device such as a mobile telephone, by virtue of the fact that the wiring patterns 32, through-holes 34, RF passive components 36 and

the shielding ground electrode pattern 38 are formed internally of the multi-layered substrate 12.

[0015]

This RF module permits reduction in the number of wiring patterns which are formed on the surface of the multi-layered substrate 12 to interconnect components, thus offering improved RF characteristics.

[0016]

This RF module 10 exhibit further improved RF characteristics if ceramics dielectric materials are used to form the multi-layered substrate 12 while highly conductive materials such as Cu or Ag are used as the material of the wiring patterns and electrode pattern inside the multi-layered substrate 12.

[0017]

In this RR module 10, control components such as the BBIC 14, memory IC 16 and so forth are mounted on the upper side of the multi-layered substrate 12, while RF components such as the first RFIC 26 and the second RFIC 28 are mounted on the lower side of the multi-layered substrate 12, thus allowing reduction in the surface area of the multi-layered substrate 12 through effective use of both sides of the same.

[0018]

In this RF module 10, control components such as the BBIC 14 and the memory IC 16 and the RF components such as

the first RFIC 26 and the second RFIC 28 are shared to both sides of the multi-layered substrate 12, so that the wiring pattern leading to the control terminals of the control system and the wiring pattern leading to the control terminal of the RF system are shortened, thus contributing to a reduction in the size of the RF module.

[0019]

In this RF module 10, the components of the control system are formed on an upper layer of the multi-layered substrate 12, while the components of the RF system are formed on a lower layer of the multi-layered substrate 12, with the shielding ground electrode pattern 38 intervening therebetween, so that the control system and the RF system are isolated from each other by the shielding ground electrode pattern 38. Consequently, interference of signals between the control block including the BBIC 14 and the memory IC 16 and the RF block including the first RFIC 26 and the second RFIC 28 is avoided to achieve a higher stability of operations of the respective blocks.

[0020]

In this RF module 10, the first RFIC 26 and the second RFIC 28 are embedded in the cavity 24 formed in the lower side of the multi-layered substrate 12, thus achieving flatness of the lower surface of the module, which in turn makes it possible to use ordinary I/O electrodes. This RF

module therefore enables surface mounting even when a double-sides substrate is used.

[0021]

Furthermore, in this RF module 10, the first RFIC 26 and the second RFIC 28 are bare chips and, therefore, can easily be mounted in the cavity 24, thus contributing to further reduction in the size of the RF module.

[0022]

Fig. 3 is a front elevational diagrammatic illustration of another embodiment of the RF module in accordance with the present invention. In the RF module shown in Fig. 3, the resin 30 used in the RF module 10 of Fig. 1 to fill the cavity 24 is substituted by a metallic cap 31 which is fixed to the multi-layered substrate 12 so as to seal the cavity 24.

[0023]

The RF module 10a shown in Fig. 3 offers an advantage over the RF module 10 of Fig. 1 in that the metallic cap 31 also serves as a shield for the first RFIC 26 and the second RFIC 28.

[0024]

Fig. 4 is a perspective view of still another embodiment of the RF module in accordance with the present invention. Fig. 5 is a front elevational diagrammatic illustration of this RF module, while Fig. 6 is an

equivalent circuit diagram of an antenna of the same. The RF module 10b shown in Fig. 4 has a multi-layered substrate 12b which is slightly greater than that of the RF module 10a shown in ~~Fig~~. 3, and a spiral antenna 40 ~~having an~~ electrode pattern and through-holes is incorporated in the RF module 10b.

[0025]

Fig. 7 is a perspective view of a yet another example of the RF module in accordance with the present invention. Fig. 8 is a front elevational diagrammatic illustration of this RF module, while Fig. 9 is an equivalent circuit diagram of an antenna of the same. The RF module 10c shown in Fig. 7 has a multi-layered substrate 12c which is slightly greater than that of the RF module 10a shown in Fig. 3, and an antenna 40 made of a loop-shaped metallic sheet is incorporated in the upper surface of the multi-layered substrate 12c. In addition, a matching capacitor 42 also is incorporated internally of the multi-layered substrate 12. The antenna may be formed of a combination of the loop-shaped metallic sheet and the metallic case 22, or of the metallic case 22 alone.

[0026]

The RF module 10b shown in Fig. 4 has the antenna 40 incorporated in the multi-layered 1substrate 2b, and the RF module 10c shown in Fig. 7 has the antenna 41 and the

matching capacitor 42 incorporated in the multi-layered substrate 12c. Therefore, these RF modules 10b and 10c can have reduced sizes as compared with the cases where the antenna is externally mounted.

The RF module 10 shown in Fig. 1, when an antenna is externally mounted thereon, requires a work at the user's end for achieving matching between the antenna and the wireless device.

In contrast, the RF module 10b shown in Fig. 4 and the RF module 10c shown in Fig. 7 eliminate the needs for such a work for establishing matching to be done at the user's side, because these RF modules can be designed to inherently have the matching, by virtue of the incorporation of the antenna 40 or both the antenna 41 and the matching capacitor 42.

[0027]

Fig. 10 is a diagrammatic plan view of a further embodiment of the RF module in accordance with the present invention, Fig. 11 is a front elevational diagrammatic illustration of the RF module, Fig. 12 is a diagrammatic bottom plan view of the RF module, and Fig. 13 is a block diagram showing patterns including a trimming electrode pattern of a resonator incorporated in the RF module.

Thus, the RF module 10d shown in Fig. 10 features an oscillator trimming electrode pattern 44 and other patterns formed on the upper side of the multi-layered substrate 12d.

At the same time, the RF module 10d shown in Fig. 10 has a ground electrode pattern for preventing RF signal radiation 46 formed on the bottom side of the RFIC 26 in the multi-layered substrate 12d.

Further, the RF module 10d shown in Fig. 10 has a plurality of via holes 48 formed in the multi-layered substrate 12d so as to surround the RFIC 26. The ground electrode pattern for preventing RF signal radiation 46 and the metallic cap 31 are electrically connected to each other through these via holes 48.

[0028]

The RF nodule 10d shown in Fig. 10 is so configured as to enable adjustment of the frequency characteristics such as oscillation frequency and filter characteristics, through trimming of the trimming electrode pattern 44 by means of, for example, laser, while monitoring or measuring the total output waveform or total performance of the wireless section, as shown in Fig. 13. This allows the adjustment to be conducted based on the final characteristics obtained in the final structure incorporating circuits such as the built-in filter and an IC amplifier. It is therefore possible to stabilize the characteristics of the products and to improve the yield.

Further, in the RF module 10d shown in Fig. 10, the RFIC 26 is surrounded by the ground electrode pattern for

preventing RF signal radiation 46, the via holes 48 and a metallic cap 31, thus preventing wasteful radiation of the RF signals from the RFIC 26. This serves to suppress coupling between different circuits, contributing to stabilization of the characteristics. In the RF module 10d shown in Fig. 10, the metallic cap 31 may be substituted by a resin filling the cavity 24 formed in the multi-layered substrate 12d. Such an alternative arrangement produces the same advantages as those described above, provided that a ground electrode pattern is formed on the substrate mounting the RF module 10d.

[0029]

In each of the RF modules described hereinbefore, the RFIC is a bare chip. The invention, however, does not exclude the use of bare chips constituting ICs other than the RFIC.

[0030]

Each of the RF modules described heretofore has only one cavity formed in the multilayered substrate. The invention, however, does not exclude the use of two or more cavities formed in the multi-layered substrate.

[0031]

It is also possible to employ two or more trimming electrode patterns.

[0032]

[Advantages]

The present invention provides an RF module which is so small as to be mountable in, for example, a mobile telephone.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a front elevational diagrammatic illustration of an RF module in accordance with the present invention.

[Fig. 2]

Fig. 2 is a circuit diagram of the RF module shown in Fig. 1.

[Fig. 3]

Fig. 3 is a front elevational diagrammatic illustration of another embodiment of the RF module in accordance with the present invention.

[Fig. 4]

Fig. 4 is a perspective view of still another embodiment of the RF module in accordance with the present invention.

[Fig. 5]

Fig. 5 is a front elevational diagrammatic illustration of the RF module shown in Fig. 4.

[Fig. 6]

Fig. 6 is an equivalent circuit diagram of an antenna of the RF module shown in Fig. 4.

[Fig. 7]

Fig. 7 is a perspective view of a yet another embodiment of the RF module in accordance with the present invention.

[Fig. 8]

Fig. 8 is a front elevational diagrammatic illustration of the RF module shown in Fig. 7.

[Fig. 9]

Fig. 9 is an equivalent circuit diagram of an antenna of the RF module shown in Fig. 7.

[Fig. 10]

Fig. 10 is a diagrammatic plan view of a further embodiment of the RF module in accordance with the present invention.

[Fig. 11]

Fig. 11 is a front elevational diagrammatic illustration of an RF module shown in Fig. 10.

[Fig. 12]

Fig. 12 is a diagrammatic bottom plan view of the RF module shown in Fig. 10.

[Fig. 13]

Fig. 13 is a block diagram showing circuit patterns including a trimming electrode pattern of a resonator incorporated in the RF module shown in Fig. 10.

[Reference Numerals]

10, 10a, 10b, 10c, 10d: RF module

12, 12b, 12c, 12d: multi-layered substrate

14: BBIC

16: memory IC

18: quartz oscillator

20: surface-mount component

22: metallic case

24: cavity

26: first RFIC

28: second RFIC

30: resin

31: metallic cap

32: wiring pattern

34: through-hole

36: RF passive component

38: shield ground electrode pattern

40, 41: antenna

42: matching capacitor

44: trimming electrode pattern

46: ground electrode pattern for preventing RF signal radiation

48: via hole